Gustatory Evoked Potential Induced by Stimulation of Solution In Human

Byung-Chan Min[**], **Se-Jin Park**[*], **Kazuyoshi Sakamoto**[**]

[**]*Ergonomics Lab., Department of Communications and Systems, The University of Electro-Communications,1-5-1 Chohugaoka, Chofu City 182,Japan*

[*]*Ergonomics Lab., Korea Research Institute of Standards &Science(KRISS),Taejon,Korea*

abstract

The evoked potentials for concentrations of solutions of the four qualities of tastes(i.e.,sweet, salty, sour, and bitter tastes) were measured. The solution was applied to the chorda tympani nerve located on the left side of the tongue at 20mm from the tip and 15mm left from the center line. The evoked potentials were detected from Cz referred to A1(left lobe) with the ground at the Fpz position. The Maximum potential level and its latency were evaluated. The individual threshold level of concentration of the solutions of four tastes were measured. Artificial saliva was used as a control solution. The evoked positive potentials for four qualities of tastes (i.e., gustatory evoked potentials) were found to be around 150ms by averaging eight responses. The arbitrary concentration of the solutions were presented by the relative concentration, which was the ratio of the arbitrary concentration to the individual threshold level.The characteristic relations between the latency and the relative concentration ;and those between the potential level and the relative concentration were evaluated. These evaluations showed that (1) the latencies for salty and bitter tastes denoted the minimum values due to for the change of relative concentration, and that (2) the latency for sour taste decreased as the relative concentrations increased, while the latency for sweet taste denoted the inverse tendency. Significant differences between any two maximum potential levels were not recognized. A response latencies to sucrose were abolished after treatment of tongue by a sweet-suppressing agent.

key words: gustatory evoked potentials , chorda tympani nerve ,Artificial saliva , relative stimulus concentration, sweet-suppressing agent.

1. Introduction

Recording of gustatory evoked potentials as a method for objective evaluation of tastes was first attempted by Funakoshi and Kawamura[1], followed by Kobal[2] and Platting[3], but a clinically applicable method has not yet been established.In the present study, employing the gustatory stimulation device developed by Min and

[**] Correspondence to .Tel.:+81 424 83-2161 Ext.3523; fax:+81 424 98-0541; e-mail: min @cocktail.cas.uec.ac.jp

Sakamoto[4,5], gustatory evoked potentials were correctly measured and recorded by varying the concentrations of solutions of four qualities of taste (sweet, salty, sour, and bitter) by averaging technique.Since taste is a chemical response, the individual difference is significant.Accordingly, the individual threshold level of taste solution was determined, and a relative concentration which arbitrary solution concentration was divided by the individual threshold level was expressed.Evoked potentials were measured for the four qualities of taste, and, considering the maximum amplitude of each quality of taste and the corresponding latency, the features regarding the four qualities of taste were studied.The pretreatment of the tongue with a sweet-suppressing agent[6,7] of chew gum containing gymnemate. Show the suppresion of characteristic amplitude for sweet solution, so that the amplitude was proved to be the sweet solution.

2. Method

Potentials were recorded using a Neuro-Pack 8 of Nippon Koden (Japan).The time constant of the amplifier was 0.3sec, and the high-cut filter was 30Hz. The recording position of gustatory evoked potential is Cz(vertex) and A1(reference electrode) on the left lobe, and the ground was set on the Fpz(frontal median).The evoked potentials were measured by monopole induction between Cz and A1.The stimulation of the taste solution was performed eight times and the waveform of each evoked potential was recorded, and after the measurement the results were processed by averaging and superimposing techniques.The site of stimulation was 20mm from the tip of the right side of tongue on the center line (Fig.1). Four taste solutions were prepared at four levels of concentration, namely, 0.01M, 0.1M, 1M, and 2M of sucrose, 0.01M, 0.1M, 1M, and 5M of sodium chloride, 0.0012M, 0.012M, 0.12M, and 0.6M of tartaric acid, and 0.00003M, 0.0003M, 0.003M, and 0.03M of quinine-HCl.Moreover, in order to detect evoked potentials due to the sweet-suppressing agent, the four taste solutions were also used at the concentrations corresponding to the minimum latency, namely, 0.1M of sucrose, 1M of sodium chloride, 0.12M of tartaric acid, and 0.03M of quinine-HCl.The sweet-suppressing agent was gymnemate gum (Meiji Seito Co.Ltd.,Tokyo,Japan). As the control solution,artificial saliva(Teijin Co.Ltd., Osaka, Japan) was used for the comparison with the evoked potentials of taste qualities.Solutions used in measurement of evoked potentials by taste solution stimulation were first applied on the basis of the concentration of the threshold level cited in the literature (Table.1).In the stimulation operating procedure, (1) the mouth was rinsed in distilled water in order to eliminate the effects of the saliva on the tongue. In the tongue pushed slightly forward, the operator held the tip

of the tongue with a piece of gauze, and presented the control solution (artificial saliva).At this time, the evoked potentials were measured. (2)The taste solutions were applied and the evoked potentials were measured.At the end of each measurement, the subject was asked about presence or absence of recognition of taste given, and if the taste was not recognized, the data was removed.

Table 1. Characters of four quality of taste used.

Substance	Sweet	Salty	Sour	Bitter
	Sucrose	Sodium chloride	Tartaric acid	Quinine-HCl
Formula	$C_{12}H_{22}O_{11}$	NaCl	$C_4H_6O_6$	$C_{20}H_{24}N_2O_2.HCl.2H_2O$
Mol.Wt.	342.3	58.5	150.1	396.9
Saturated Con.(M)	5.96	6.10	9.26	0.12
Thresholds(M)	0.01[8)]	0.01[8)]	0.0012[8)]	0.00003[8)]

The number at figure denotes the literature number.

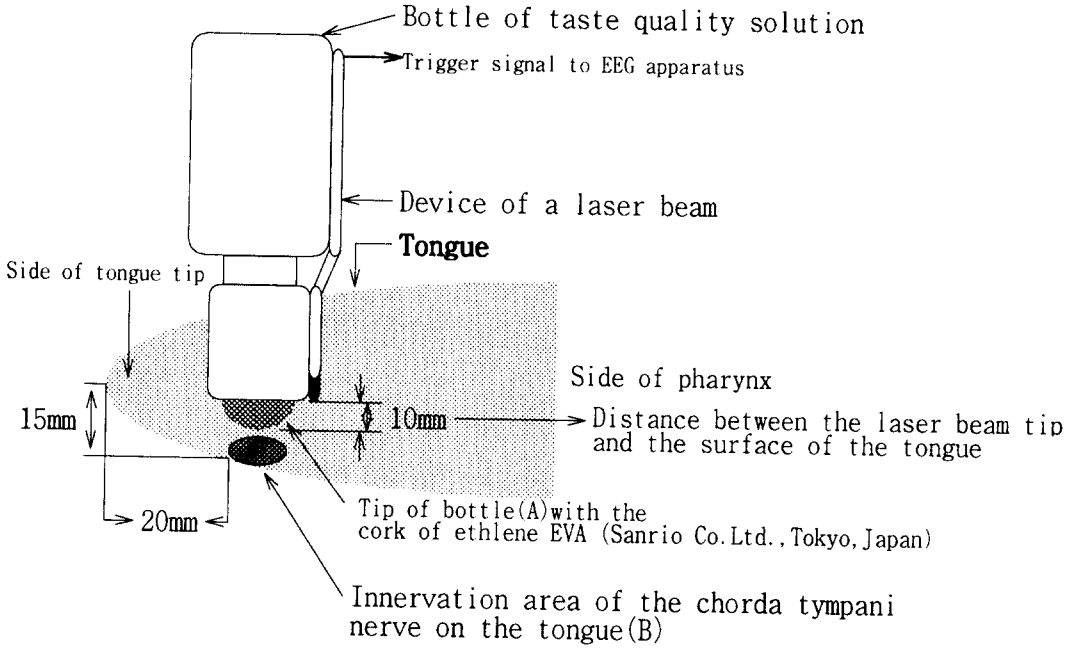


Fig 1. The schematic drawing of the device for gustatory stimulation. The taste solution in a bottle touched to the tongue surface of the human and the moment touched was accurately detected by an device using a laser beam,and the signal evaluated as a trigger. The shape of a taste quality solution bottle has diameter 18mm and height 50mm .

A interval of 10 minutes was provided until testing at the next concentration, in order to eliminate adaptation and fatigue of the tongue.In this study, the stimulation time was 2 seconds, and the solution stimulation interval was 60 seconds.The temperature

of both all taste solutions and the control solution was 35℃ (equal to body temperature) so as to eliminates the effects of warm sensation. As the threshold inspection method, the threshold concentrations were set to seven equal intervals.In the threshold inspection, by the absolute judging method, the recognized threshold level was determined as the threshold of the taste.The subjects were 10 healthy men (aged 23 to 26) with normal gustatory senses. All subjects were non-smokers, and were restricted from drinking or eating anything for at least one hour before start of test.The taste solution was presented in a closed-eye state.The measuring time was from 2 to 6 o'clock in the afternoon.

3.Results and discussion

For evoked potentials by stimulation of taste solution, evoked potentials of same solution and same concentration at different sites of stimulation were added, and the average evoked potential was determined.

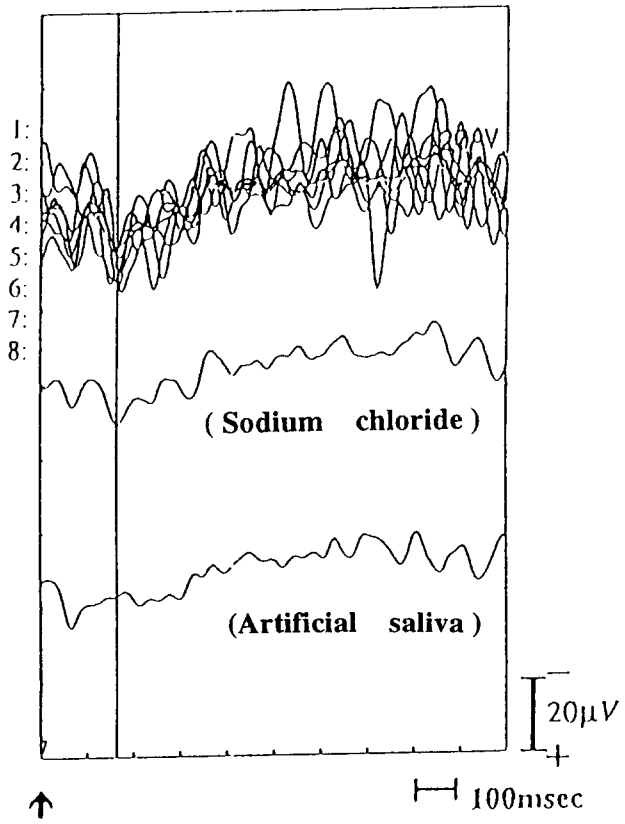


Fig 2-A. Gustatory evoked potentials by the typical averaging and superimposing techniques to 1M sodium chloride solution. Arrow indicates the oneset of stimulation. Geps was apparent for all four quality of taste.

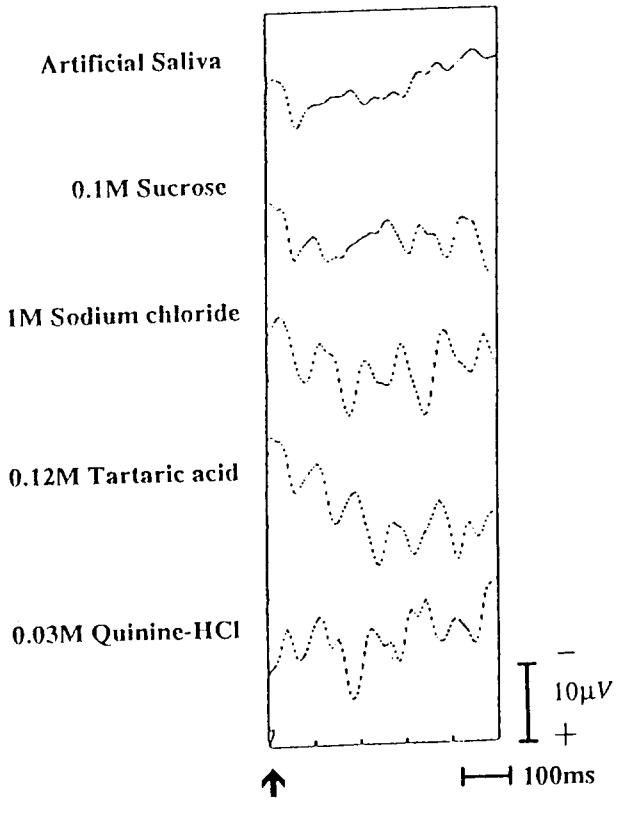


Fig 2-B. Gustatory evoked potentials of four quality of taste and artificial saliva after treatment of sweet-suppressing agent (chewing gum)for 15min.

The average waveforms of evoked potentials of the artificial saliva as control are shown in Fig. 2-A and Fig. 2-B.As shown in the diagrams, no particular response around 150ms to artificial saliva was noted; although a peak (P1) was seen in the first 60ms, it was not a response waveform characteristic of the control, but it was also seen Fig. 2-B.The evoked potential to three types of taste solution stimulation except for sucrose 15 min after chewing gymnemate gum.About 150ms after taste solution stimulations was not noted.As can be seen from these results, before and after the treatment of the sweet-suppressing agent, there was no change in susceptibility to salty taste (sodium chloride), sour taste (tartaric acid) and bitter taste (quinine-HCl), but the response waveform near 150ms for sweet taste stimulation was suppressed. Incidentally, peak P1 near 60ms is considered to be a response waveform due to sensations except for gustatory response, such as touch and pressure senses.Table 2 summarizes the minimum latency at the maximum evoked potential of the four qualities of taste to taste solution stimulation.According to Yamamoto[9], the sour taste of 0.025M (tartaric acid) can be distinguished about 200ms from the start of excitation of the nerve in the gustatory region of the cerebral cortex.The time until the gustatory nerve information is interpreted in the brain (neuro-coding time)[10] is reported to be less than 200ms in the case of stimulation of 0.5M of sodium chloride.

Table2. The minimum Latencies and amplitudes at the maximum gustatory evoked potential elicited by four qualities of taste.

Taste quality	(M/*l*)	latencies mean±S.D.(ms)	amplitudes mean±S.D.(μV)
Sweet	0.10	133.4±14.2	17.6±6.4
Salty	1.00	140.5±27.3	13.1±5.1
Sour	0.12	126.9±21.8	13.4±4.8
Bitter	0.03	149.7±34.7	11.4±5.0

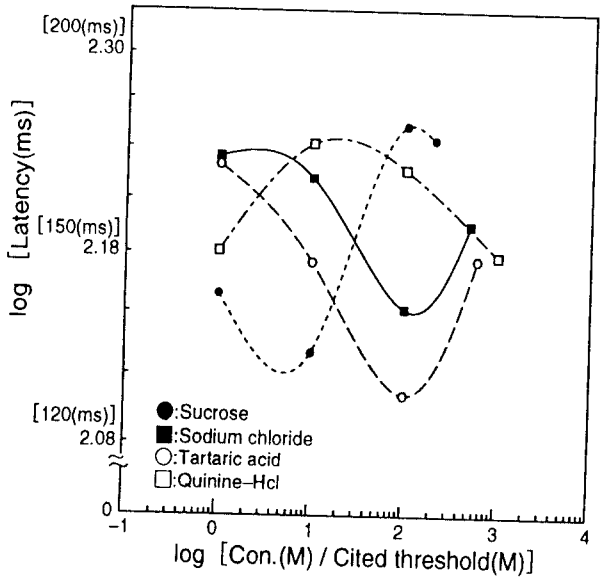
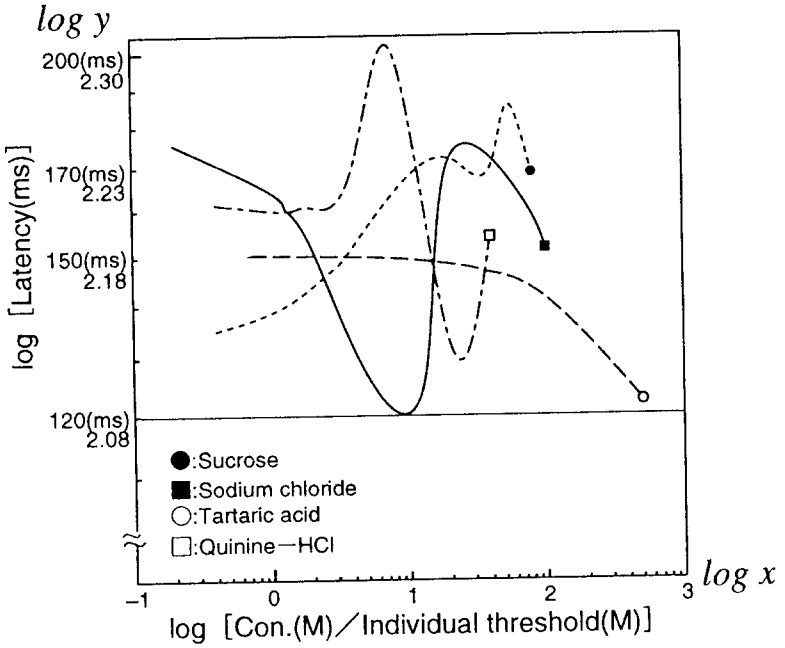


Fig3. Relation between the latencies and the relative concentration for the maximum evoked potential based on the cited threshold.

Therefore, the latency of evoked potentials obtained in the present method seems

to be a reasonable time.It was attempted that the concentration was to expressed as the relative values on the basis of the threshold concentration.First, using the concentration at the threshold cited from the literature (cited threshold in Table1), the results of relative concentration and latency are as shown in Fig.3. By statistical verification, the difference between the latency at the threshold concentration shown and the minimum latency, is noted by a level of significance of 5% and 1% for salty taste and sour taste respectively.For sweet taste, a significant difference of 1% between the latency at threshold concentration and maximum latency was noted, but there was no significant difference between the latency at threshold concentration and minimum latency. For bitter taste, there was no significant difference in the measured latency.



Sucrose : $y = 132.722 + 5.919x - 0.302x^2 + 0.006x^3 - 3E-05x^4$

R=0.69 n=39 ＊＊: p<0.01

Sodium chloride: $y = 178.765 - 15.598x + 1.147x^2 - 0.022x^3 + 1E-04x^4$

R=0.63 n=39 ＊＊: p<0.01

Tartaric acid : $y = 160.63 - 0.604x + 0.006x^2$

R=0.25 n=39 ns

Quinine-HCl : $y = 163.098 - 5.325x + 2.354x^2 - 0.161x^3 + 0.003x^4$

R=0.56 n=39 ＊: p<0.05

Fig 4. Relation between the latencies and the relative concentration for the maximum evoked potential based on the individual threshold.

The bitter taste provided the minimum latency at about 10^3 times of the threshold concentration, the sweet taste at about 10 times, and the sour taste and salty taste at about 10^2 times. The individual difference is,however, significant in taste,so that the

results in Fig. 3 should be reconsidered.Accordingly, instead of using the relative concentration based on the cited threshold concentration the relative values due to individual threshold concentration were employed. The results are shown in Fig. 4. Hence, in the curve in Fig. 4, when the order is determined by multiple regression analysis so that the adjusted R squared is a maximum, the regression function is obtained as a quartic polynomial equation.This curve is more complicated than in Fig. 3, and the interpretation of the latency to the presented concentration is also different.The relative concentration range of bitter taste, which was 10^3 times at the cited threshold, is narrowed to 40 times.In this narrow relative concentration range, maximum and minimum latencies are recognized.As for the sweet taste, using the cited threshold concentration, the minimum latency existed but by using the individual threshold concentration, it shows that the latency has minimum at the threshold concentration. The latency extended as the relative concentration increased.For the sour taste, as with the sweet taste, when using the cited threshold, the minimum latency was obtained in the range of the presented relative concentration, but by using the individual threshold concentration, the latency decreases monotonously as the relative concentration becomes larger.The salty taste, at the cited threshold concentration, presented the minimum latency at the minimum relative concentration of 10^2, but when the relative concentration is expressed using the individual threshold concentration, the change of latency was obtained as if in a mirror-image relation with the change of relative concentration of bitter taste (Fig. 4).In the relative concentration range, the minimum latency was presented at about 10 times of the individual threshold, and the maximum latency was obtained at the relative concentration of about 30 times.Comparing Fig. 3 and Fig. 4, the minimum latencies of salty taste and bitter taste are shortened to 120ms and 130ms, and it is characteristic that the fluctuation of latency due to relative concentration change is significant.In the present study, although there was no significant difference in the amplitudes between the cited threshold and each relative concentration, the amplitude at 0.003M concentration for bitter taste was significantly larger than the threshold at the threshold concentration.In the case of sodium chloride, the amplitude tended to increase from the concentration of 0.01M of low stimulation concentration to the concentration of 0.5M. Platting[3],using sophisticated gustatory stimulation that delivered taste solutions to the tongue surface, described a negative (410ms)-positive (1200ms) complex produced by solutions of sodium chloride. Effects of stimulus intensity and duration on potential amplitude and latency were demonstrated, as was a dependence on tastant used. In the visual evoked potentials, when the luminance was decreased, it was reported that the P100 latency was extended but the amplitude was not influenced[11].Considering these results, it was suggested that the amplitude was saturated and not changed further when exceeding a certain stimulation strength.

4.Conclusions

1) The taste solution stimulating chloride tympani nerve on the tongue was accurately detected by an device using a laser beam,and the stimulation was evaluated as a trigger signal.

2)On the basis of individual threshold for taste solution the relation between the relative concentrations of the taste solutions and the latency with the maximum evoked potential was determined.The maximum evoked potential was evaluated for various relative concentration.

3)Before and after application of the sweet-suppressing agent, there was no change in susceptibility to salty taste (sodium chloride), sour taste (tartaric acid), and bitter taste (quinine), but the response waveform near 150ms for sweet taste stimulation was suppressed.Incidentally, the peak P1 near 60ms is considered to be a response waveform due to sensations except for gustatory response, such as touch and pressure senses.

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